National Aeronautics and Space Administration

Aeronautics Testing Facilities Overview

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Who is NASA Glenn?

Lewis Field (Cleveland)

- 350 acres
- 1626 civil servants and 1511 contractors
- 66% of workforce are scientists and engineers

Plum Brook Station (Sandusky)

- 6500 acres
- 11 civil servants and 102 contractors

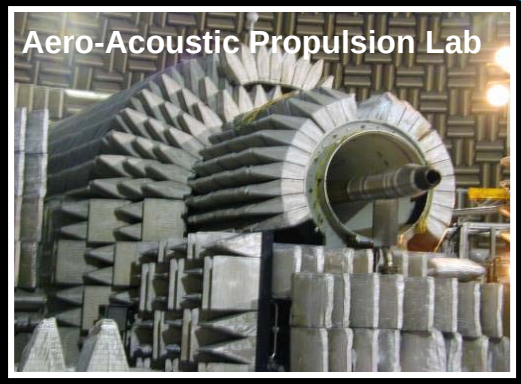
NASA GRC Unique Aero Test Facilities

Subsonic Propulsion Wind Tunnels

- Noise suppression
- Inlet/Airframe integration
- STOVL hot gas ingestion

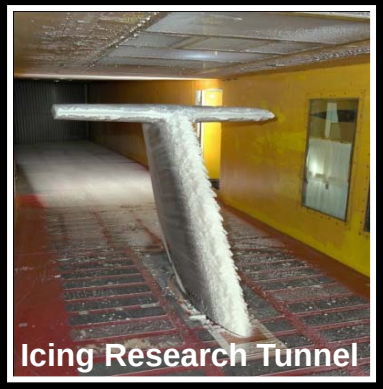
Transonic and Supersonic Propulsion Wind Tunnels

- Advanced propulsion concepts
- Inlet/Airframe Integration
- Internal/external aerodynamics



Engine Acoustic Research Facility

- Fan/nozzle acoustics research
- Simulate hot engine nozzles in flight
- Aerodynamic and Aeroacoustic measurements capabilities



Largest Icing Tunnel in US

- Aircraft icing certification
- Ice protection systems development
- Icing prediction/code validation

NASA’s only altitude full-scale engine facility

- Jet Engine Icing Research
- Engine operability/performance
- Nozzle-engine integration/development

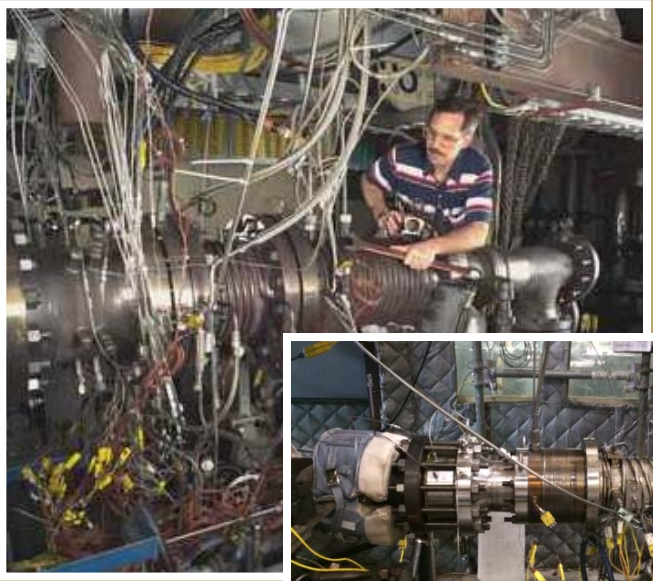
Over 50 Versatile Engine Component Facilities

- Combustor and Heat Transfer
- Compressor and Turbine
- Inlets and Nozzles

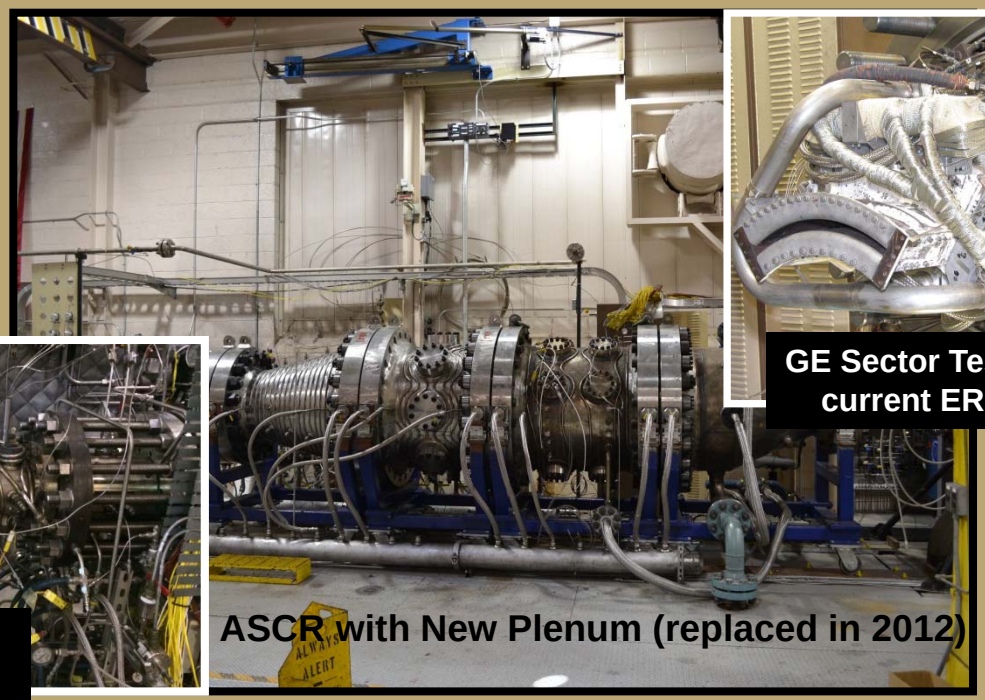
Aero-Acoustic Propulsion Lab (AAPL)
Nozzle/Fan Acoustic Test Rigs

- Acoustic Dome Built in early 1990's to support Nozzle Noise Reduction Research:
  - Nozzle Acoustic Test Rig (NATR): Free Jet Acoustic Tunnel (Mach 0.30, 4 Ft Diameter); microphone array outside tunnel flow, Jet Exit Rig simulates engine exit conditions.
  - Advanced Noise Control Fan (ANCF): Built in 1995 for low TRL fundamental research (4 ft dia. fan, 2200 RPMs).
  - Small Hot Acoustic Jet Rig (SHAJR): Built in 2000 for low TRL nozzle research (no flight flow). About 1/10th cost of NATR, appropriate to screen nozzle concepts to test in NATR.

Engine Research Building (ERB) Combustor Facilities



CE-5B Stand 1, LDI Concept Supersonic Combustor tested in Stand 2



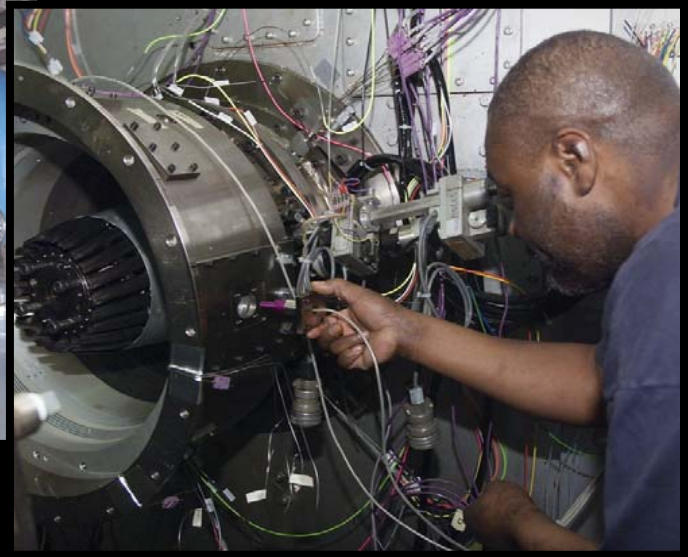
ASCR with New Plenum (replaced in 2012)

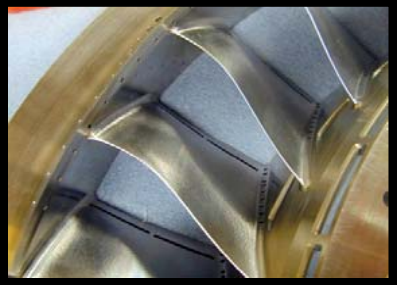
GE Sector Tests (not current ERA concepts)

- Advanced Subsonic Combustor Rig (ASCR) supports higher pressure combustor testing (900 PSIG, 1300 F inlet and 50 lb/sec air flow)
- CE-5B Intermediate pressure combustor facility (450 PSIG, 1350 F and 10 lb/sec air flow) with extensive non intrusive instrumentation capabilities
- Various others smaller combustor research facilities for fundamental understanding of flame instability, combustion acoustics, and alternative fuel understanding

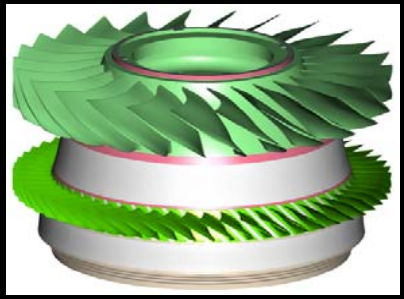
Engine Research Building (ERB)
Turbo-Machinery Facilities

CE-18 Centrifugal Compressor Test Facility



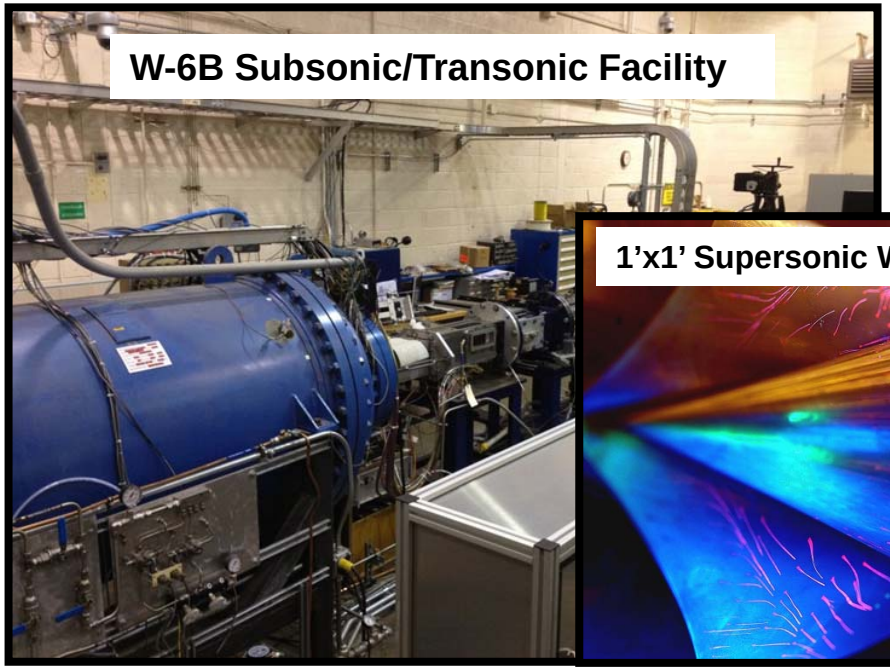


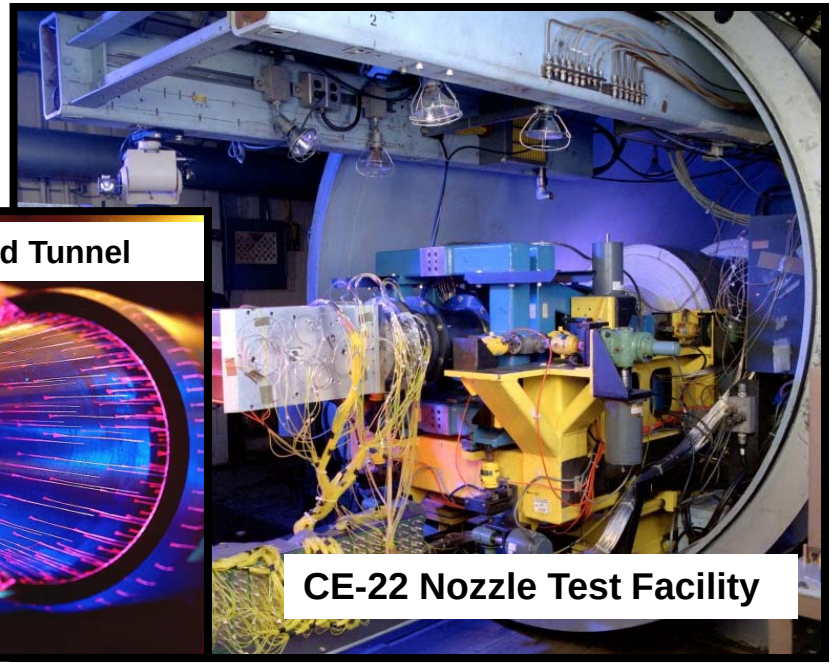
W-7/8 Compressor Test Facilities



- Suite of combustor and turbine mid size facilities:
  - W-1A (Low-speed compressor): 60/48”, 1 500 HP, 1 920/1 050 RPM
  - W-7 (Multi-stage compressors): 22”, 15 000HP, 18 700 RPM
  - CE-18 (Centrifugal compressors): 20”, 6 000 HP, 60 000 RPM
  - W-8 (Single-stage compressors): 22”, 7 000 HP, 20 600 RPM
  - CW-22 (Turbine Blade Cascade): Large scale, large range of M and Re Number
  - W-6A (Single Spool Turbine Facility): Continuous flow turbine facility

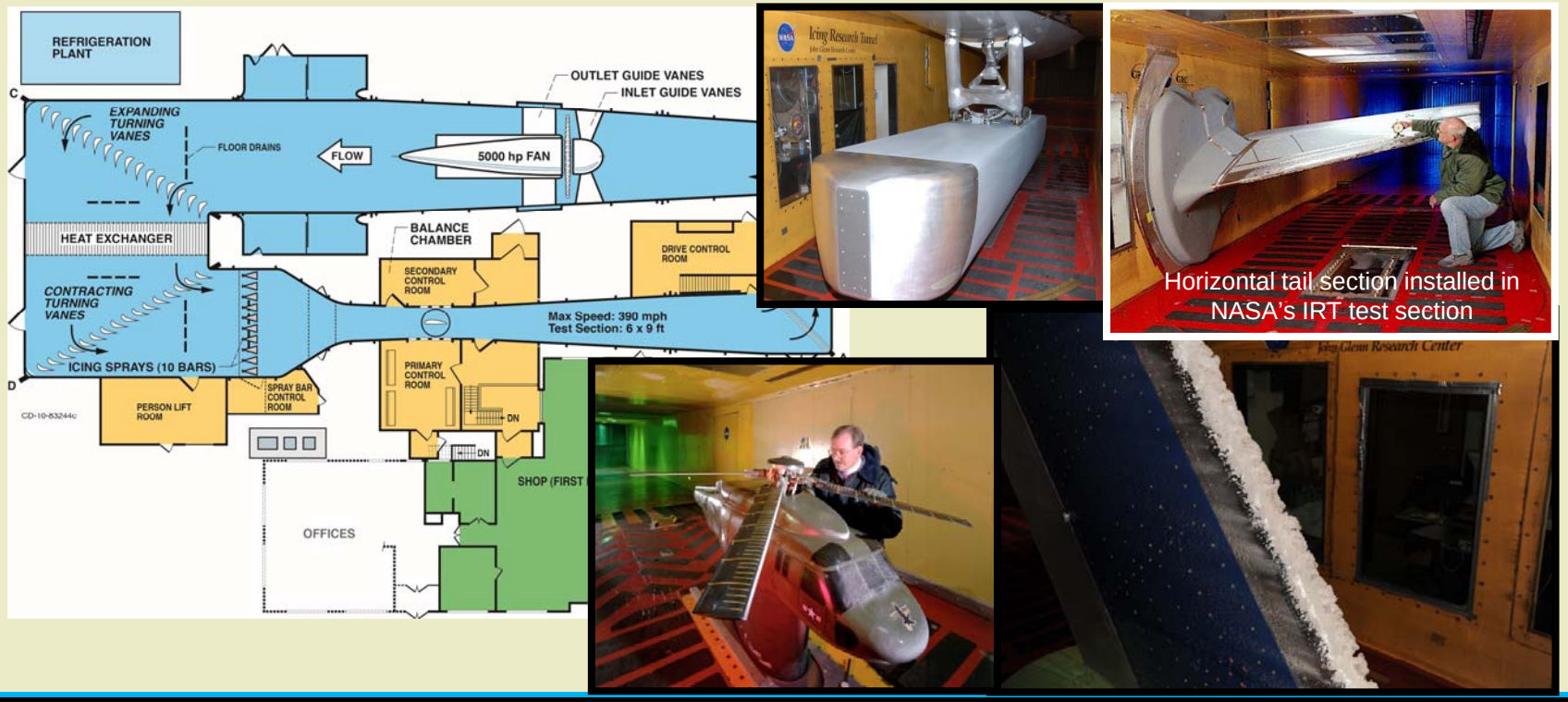
Engine Research Building (ERB)
Flow Physics Facilities





- Flow Physics Main facilities:
  - 1’x1’ Supersonic Wind Tunnel (test up to Mach 6.0)
  - CE-22 Nozzle Test Facility (simulate altitude nozzle thrust performance)
  - W-6B (small supersonic wind tunnel)
  - Mechanical Components test rigs (seals, gears, lubrication systems) and R&D Labs

Icing Research Tunnel

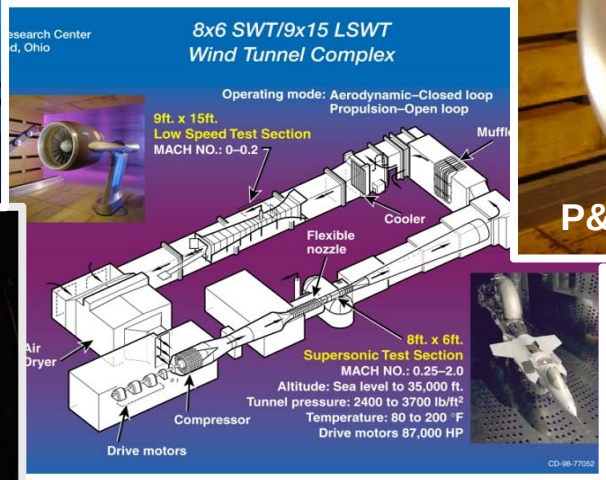


- NASA GRC's busiest facility with constant occupancy.
- Provides FAA certification of ice protection systems for military and commercial aircraft
  - 6' x 9' Ft Test Section, Speed Range 50–325 knots, Temp. = -35C
- Completed major Icing Calibration (November - February) and back to testing since March 2014.

8x6 Supersonic Wind Tunnel
9x15 Low Speed Wind Tunnel


GE Open Rotor Model 8x6


Boeing Quiet Experimental Validation Concept, QEVC, performance model 8x6

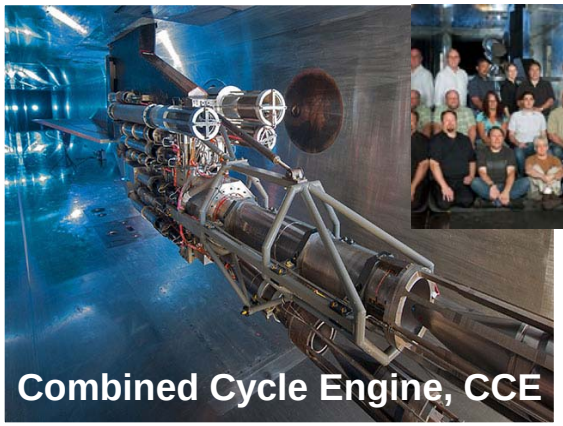


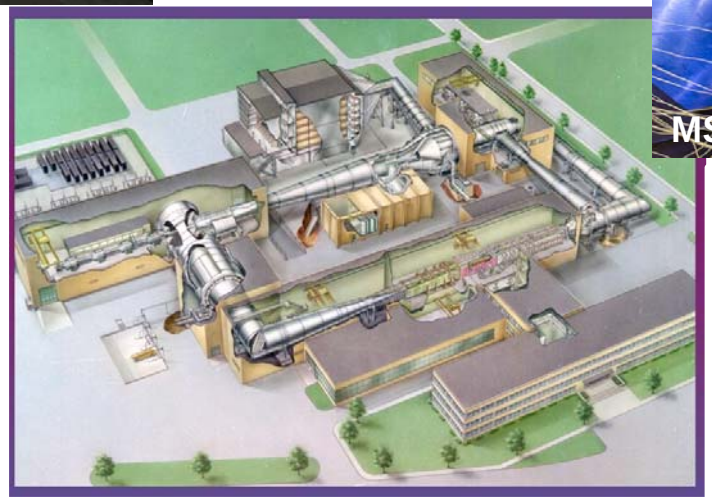

P&W GTF Model 9x15


GE Open Rotor Model 9x15

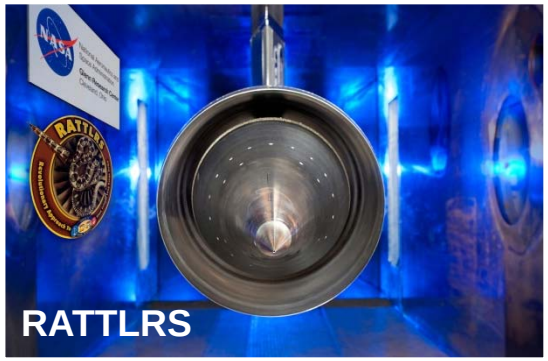
- The 8x6 provides subsonic, transonic and supersonic speed range. It operates either in an aerodynamic closed-loop cycle, testing aerodynamic performance models, or in a propulsion open-loop cycle that tests live fuel burning engines and models.
- The 9x15 specializes in evaluating aerodynamic performance and acoustic characteristics of fans, nozzles, inlets, propellers, and hot gas-ingestion of advanced Short Takeoff Vertical Landing (STOVL) systems.

10x10 Supersonic Wind Tunnel


Combined Cycle Engine, CCE



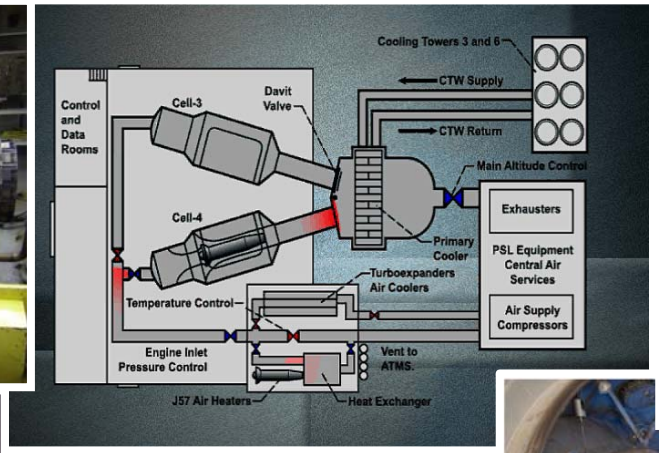

MSL Flexible Canopy Test


RATTLRS


Advanced Inflatable Decelerator for Atmospheric Reentry

- The test section can accommodate large-scale models, full-scale engines and aircraft components. The 10x10 was specifically designed to test supersonic propulsion components such as inlets and nozzles, propulsion system integration, and full-scale jet and rocket engines. It can operate as a closed-loop system (aerodynamic cycle) or open-loop system (propulsion cycle), reaching test section speeds of Mach 2.0 to 3.5 and very low speeds from 0 to Mach 0.36. Gust and Mach plates are sometimes installed to expand local Mach number conditions between Mach 1.5 and 4.1.

Propulsion Systems Laboratory (PSL)



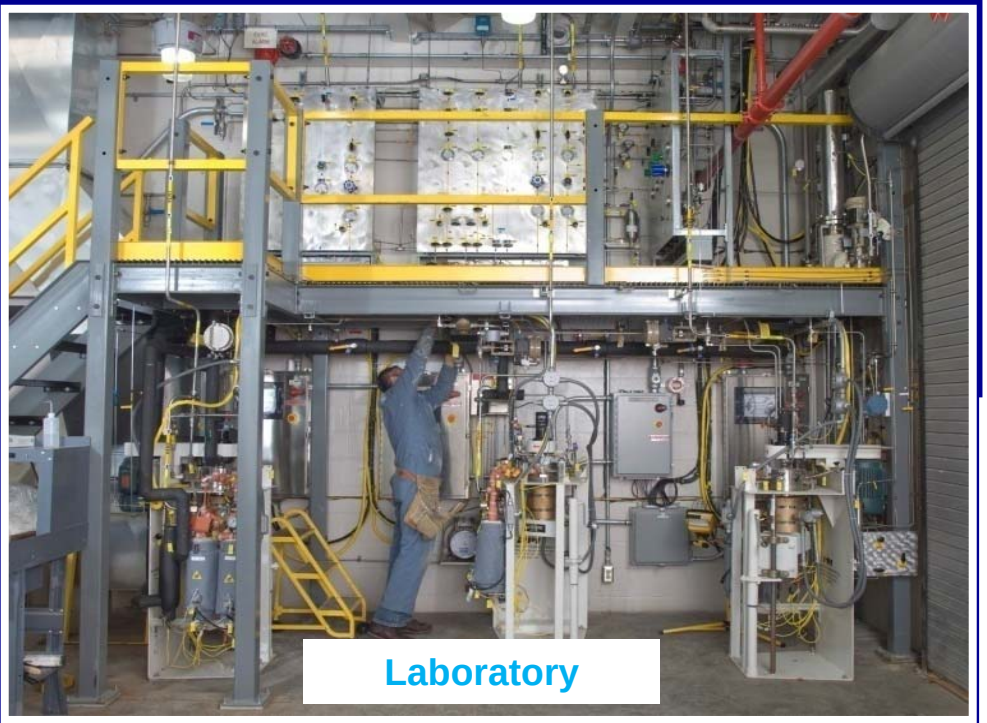
- The PSL is NASA's only ground-based test facility that provides true flight simulation for experimental research on air-breathing propulsion systems. Altitudes to 90,000 feet and Mach numbers to 3.0 in one cell and 6.0 in the other can be simulated continuously. An icing system was recently added to Cell 3 providing the capability to simulate clouds of ice crystals and liquid water droplets.

Propulsion Systems Laboratory (PSL)

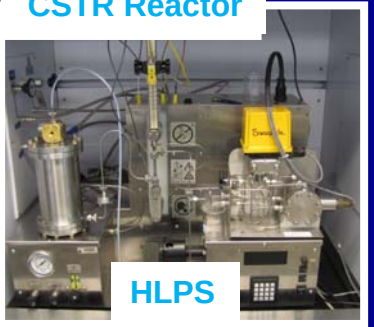
Alternative Fuels Laboratory


Control Room


Gas Chromatographs


Laboratory


CSTR Reactor


HLPS

- Complete research facility consisting of 3 Fischer-Tropsch (F-T) reactors and a comprehensive mini characterization laboratory with Gas Chromatographs and Hot Liquid Processing Simulator
- F-T synthesis converts catalyst into synthetic jet fuel
  - Improve F-T process through new catalyst development
  - Goal is to produce a cleaner and more economical alternative to traditional commercial jet fuel through reducing energy input and CO_2 emissions and increasing product yields

Aircraft Operations Office

Twin Otter DHC-6

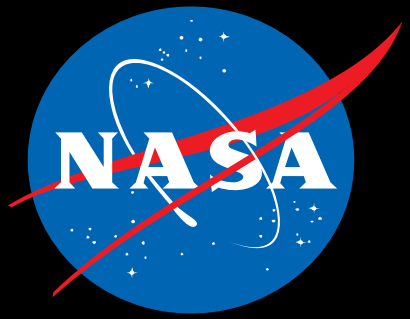
Learjet 25

S-3B Viking

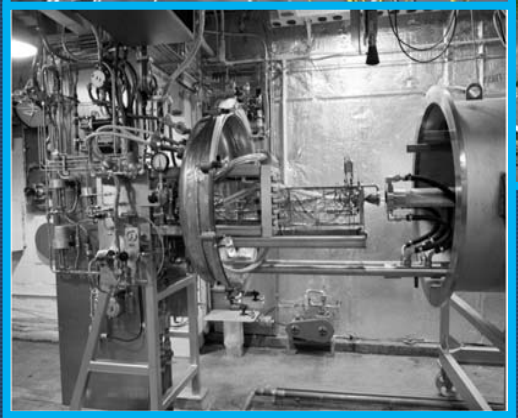
T-34 Mentor

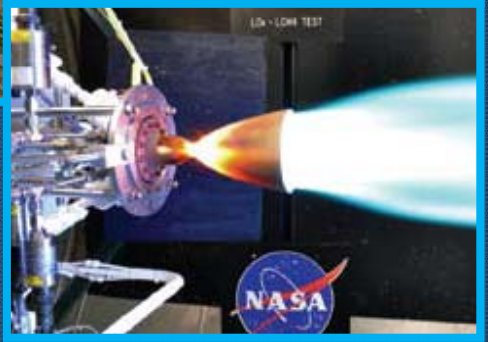
Aircraft Crew/Performance Data Comparison

	 Learjet Model 25	 Twin Otter DHC-6	 S-3B Vikings	 T-34 Mentor
Pilots	2	1 – 2	1 – 2	1
Researchers	1 – 4	1 – 3	2-3	1
Airspeed Range	150-350 KIAS (.82 Mach)	75-200 KIAS	140-450 KIAS (.79 Mach)	75-280 KIAS
Range	@ 1,000 Nautical Miles	@ 400 Nautical Miles	@ 2,300 Nautical Miles	@ 550 Nautical Miles
Ceiling	45,000 ft +	16,000 ft	40,000 ft	30,000 ft
Gross Weight	15,000 lb	11,000 lb	52,500 lb	4,400 lb
Payload	@ 3,200 lb*	@ 3,600 lb*	@ 12,000 lb*	@ 400 lb*


NASA

Research Combustion Laboratory (RCL)





- RCL is a complex of multiple test cells which supports chemical propulsion and materials testing
  - Green Propellant Infusion Mission (GPIM) – Cell 11
  - Additive Manufactured Component testing – Cell 32
  - Wave Bearing Rig – Cell 24A
- Altitude Combustion Stand (ACS)
  - Altitude testing with cryogenic conditioned propellants up to 2000 lb thrust